Automatic Toll Switching Systems

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(Manuscript received May 12, 1952)

A new automatic toll switching system has been developed by the Bell Telephone Laboratories for use at the most important switching centers for implementing the nationwide dialing program. The job of performing the switching functions at such points is the most comprehensive ever performed by any system, requiring a high order of mechanical intelligence. The new switching system uses crossbar switches for the talking connections and fully exploits the common control principle whereby the equipment used for directing the establishment of connections through the switches is provided in pools common to the office and is used with high efficiency. To perform the complicated translating functions a new device called the card translator has been developed. It uses punched metal cards and an optical system with phototransistors. Routing changes are made by insertion of previously prepared cards in the machine. The switching system was designed with the objective of handling long distance traffic dialed by customers as well as that dialed by operators.

INTRODUCTION

This paper deals primarily with the major switching centers required for the nationwide automatic switching plan. These are called Control Switching Points (CSP's) and are supplied with switching equipment endowed with great versatility and a high order of mechanical intelligence. Mr. Pilliod's paper[1] explains how for purposes of circuit layout and routing, they are assigned different rankings as follows, starting with the lowest ranking: Primary Outlets (PO's), Sectional Centers (SC's), Regional Centers (RC's) and one National Center (NC). Substantially the same equipment is to be provided for all of these centers so that they all will have inherently the same capabilities. They will, however, differ greatly in size. In the United States and Canada, as now envisaged, there will be somewhat under 100 of these CSP's.

The system which Bell Telephone Laboratories developed for use at CSP's and which embodies all of the features required at those important

switching points is based on the Toll Crossbar System[2] now in service and has been constructed by the addition of the necessary CSP features to the basic structure of that system.

FUNCTIONS OF THE CSP SWITCHING SYSTEM

The system is designed to be suitable for location in either a step-by-step or a panel-crossbar local area. In addition to the functions required for operation as a CSP, it must, of course, perform the normal toll switching functions required of any system for switching the toll traffic characteristic of the locality it serves. These may be stated very briefly.

Ordinary Toll Switching Functions

1. It accepts calls either directly from operators or from senders in distant offices. In the interest of economy it accommodates itself to the signaling language the operator's position or sender is equipped to deliver. Calls from operators may be either in the dial pulse (DP) or multi-frequency[3] (MF) form. Calls from senders will be in the MF form.

DP pulsing is the decimal type delivered directly by the dial and is at the rate of about one digit per second. MF pulsing represents a particular digit by a combination of two out of five frequencies in the voice range; it uses one of these frequencies in combination with a sixth frequency to produce a signal indicating the beginning of pulsing, and a different one of the five in combination with the sixth for an end of pulsing signal. It is transmitted from senders at the rate of about seven digits per second. Operators usually key at the rate of up to two per second.

2. The toll switching system completes calls to various types of mechanical toll and local offices and to operators, using the form of signaling dictated by economy for each call. For distant toll offices and local offices using step-by-step equipment DP will be transmitted, for other CSP's and usually for local crossbar offices MF will be transmitted and at manual toll offices an operator will be called in either automatically on seizure of the toll line or by sending a ringing signal over the line, but no pulses will be transmitted. Forms of pulsing different from either of these are used for local panel offices and for local manual offices in panel-crossbar areas.

3. It must transmit signals in one direction for initiating, holding and releasing the connection and in the opposite direction to indicate to the originating end when the called subscriber answers and hangs up. These

signals must be in a form suitable for propogation over the medium which carries them.

4. It must exercise control over the amount of amplification of voice currents introduced at the switching point so that a proper grade of transmission will be furnished.

All of these functions are performed by toll crossbar systems already in service. The features that distinguish the new system are those peculiarly characteristic of CSP operation.

CSP Functions

The following features which will be built into the equipment at Control Switching Points are commonly referred to as CSP features:

1. Storing and sending forward digits as needed.
2. Automatic alternate routing.
3. Code conversion.
4. Six-digit translation.

The first of these features is basically essential for implementation of the plan. The second produces faster service and important economies in outside plant. It also provides protection against complete interruption of service in case of failure of all circuits on particular routes. This aspect of the feature is so important that automatic alternate routing may also be considered essential. The other two features are provided for reasons of economy, and produce economies of such magnitude that they are very much worth while.

1. Storing and Sending Forward Digits as Needed

The necessity of providing this feature in CSP switching systems arises from the nature of the numbering and switching plans. The numbering plan[4] is constructed with the objective of using a minimum number of digits to give each telephone user in the country a distinctive number.

Numbers delivered to the CSP equipment are in the form ABX-XXXX if the called place is in the same numbering area as the CSP. AB represents the first two letters of any office name and X represents any numeral. If the called place is in another numbering area this set of digits will be preceded by X0X or X1X. X0X or X1X is the area code, ABX the local office code, and these are the digits used for routing purposes. Regardless of the number of switches required to complete the call, these two sets of code digits are all that will be supplied. They are universal codes in that they identify specific destinations – any place

in the United States or Canada – and for a particular destination the same set of digits will be used wherever the call may originate. All CSP's must, therefore, be able to advance a call toward the same place when the same set of digits is received.

To make use of destination codes possible, each CSP must store the digits as received and pass along to the next point whatever digits may be required there for advancing the call. If the next point is a CSP not in the home numbering area of the called place, the complete ten-digit number will be sent forward. If it is a CSP in the home numbering area of the called point the area code will be dropped and the remaining seven digits will be sent forward. That CSP may in turn complete to a local office directly, dropping the office code, or through a step-by-step TO (Tandem Outlet) or TC (Ordinary Toll Center), substituting arbitrary digits for the area or office code, thereby exercising the third of the listed CSP features.

2. Automatic Alternate Routing

The system is arranged to offer the maximum number of alternate routes possible under the switching plan. As explained by Mr. Pilliod,[1] a maximum of five alternates will actually be used. This number is possible, of course, only at PO's since higher ranking CSP's have fewer CSP's above them in the final chain.

3. Code Conversion

This refers to the ability to substitute one, two or three arbitrary digits for the area code, the office code or both. It is economically important to be able to do this because it makes it possible to work with the step-by-step equipment extensively used in local offices and in toll offices in TC's or TO's without the changes in local numbering plans or rearrangements – and in some cases extra selectors – required for the step-by-step TC's or TO's to use ABX codes for routing purposes. Even though eventually all customers are listed as ABX-XXXX and TC's are arranged to use the listed number for routing the calls, this will not be accomplished for some time. Moreover, after such arrangements are in effect there will still be need for code conversion, particularly for routing calls through TO's. Many combinations of digit dropping and substitution are required to cover all possible cases.

4. Six-Digit Translation

When a CSP receives a ten-digit number it is sometimes sufficient to translate only the area code digits and sometimes necessary to trans-

late both the area and office codes. If all points in the called area are reached by the same route out of the particular CSP concerned the area code will suffice for selection of the route. If some points are reached by one route and others by one or more different routes the office code must also be translated to determine which route should be selected.

BASIC ARRANGEMENT

In the CSP switching equipment talking connections are established through crossbar switches.[5] Incoming and outgoing toll lines and toll connecting trunks are terminated on crossbar switch frames with linkage between them to provide full access. The switches are controlled by equipment common to the office, each item of which is held only long enough to perform its task in setting up the connection.

The major items of common control equipment are senders, markers, decoders and translators. The basic functions of the senders are the same as in other common control systems, i.e., registering incoming digits and sending them out as directed. A departure from prior practice is made in the design of the marker. In other crossbar systems the marker is the principal seat of the mechanical brains. It not only controls the actual establishment of the connection but also does the translating to determine what connection should be established and what information should be passed to the sender for further disposition of the call. In this system the marker still controls the actual setting up of the connection, but it acts on instructions received from the decoder where the major portion of built-in intelligence resides.

The decoder accepts code digits from the sender, translates them, makes selection of alternate routes and gives instructions to markers and senders to enable them to carry out their assignments. To do the translating job the decoder has one, and in some cases two translators permanently associated with it and in addition has access to a common group of translators called foreign area translators which can be used by all decoders as required.

The relationship of the principal elements of the system to each other is depicted in the schematic diagram, Fig. 1.

METHODS OF OPERATION

The manner in which the various elements of the CSP system and the CSP systems at various locations cooperate to implement the nationwide switching plan may best be understood by following the progress of a call which demands the exercise of the characteristic CSP functions.

Assume an outward operator in Atlanta has received a station-to-station call for a subscriber in Monticello, Maine, whose number is ACademy 4–2345, that Monticello is a tributary of Houlton, a step-by-step TC, that Bangor is a step-by-step TO serving Houlton as its bome TO and that the circuit groups provided are as indicated in Fig. 2. The dotted lines represent high usage groups and the solid lines final groups.

The Atlanta operator plugs into a tandem trunk to the toll crossbar system in Atlanta, thereby causing a sender to be attached to the trunk through the sender link frame. This causes a lamp signal to be displayed to the operator, indicating that she may key the number. She keys 207–AC4–2345 plus a start signal (signifying end of keying) into the sender and leaves the connection to handle otber calls. She will give tbis call no further attention until the lamp associated with the cord circuit used in establishing it signifies either by flashing that the call was not completed due to a busy condition of the called line or to circuit congestion, or by going dark that the called subscriber has answered and she should start timing the call.

As soon as the area code, 207, is received by the sender it calls for a decoder and gives it the code. The decoder, by means of a self-contained translator finds that the area code is sufficient for routing purposes, that the first choice route is by way of Boston, the second New York and the final St. Louis. Without consulting other circuits it will know in wbich

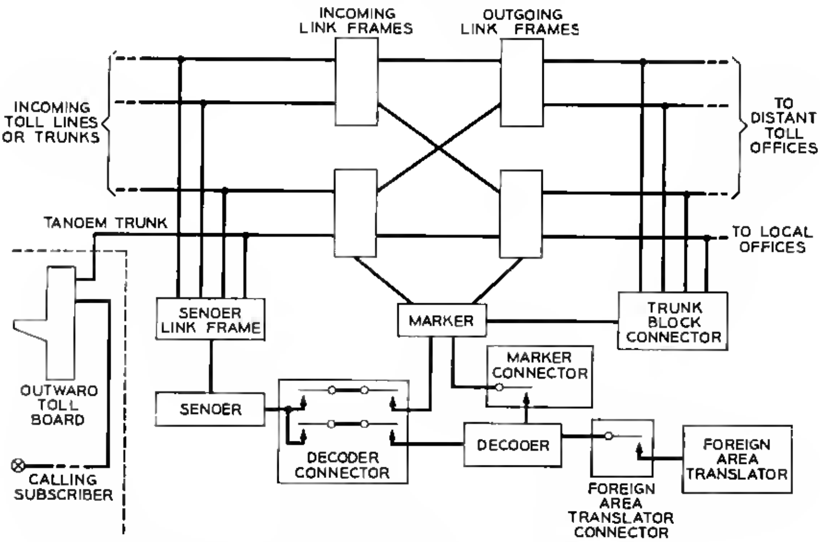


Fig. 1—Schematic diagram of crossbar switching system for CSP's.

of these groups an idle circuit may be found. Let us assume that the circuits to Boston are all busy but there are one or more idle circuits in the New York group. The decoder calls for a marker and tells it which group of leads to test, and also causes the sender to be connected to the particular marker it has selected.

The marker, following instructions from the decoder, is connected to the appropriate trunk block connector. This is one of a group of common circuits giving access to "blocks" of trunks for allowing the marker to locate an idle trunk. The marker examines the test leads of the individual toll lines to New York and as soon as it bas selected an idle circuit it so informs the decoder. The decoder then tells the sender to send all

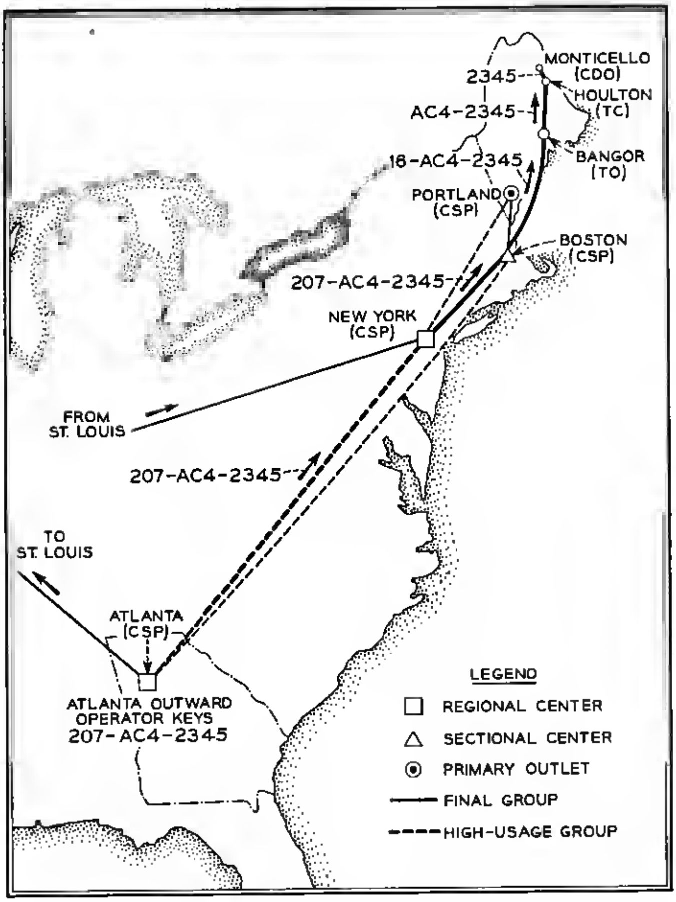


Fig. 2—Call from Atlanta, Georgia to Monticello, Maine.

digits forward by MF and leaves the connection to accept another call. This information is relayed from the decoder to the sender by way of the marker. The work time of the decoder has been in the order of a half second.

The marker determines the identity of the frames on which the incoming and outgoing circuits are located, finds an idle path between the two circuits and sets up the connection. After checking the path through the switches to be sure that there are no troubles it notifies the sender that its task has been completed and then leaves the connection. Its work time has also been in the order of a half second.

In the meantime other digits have been coming in to the sender but it does not wait for all of them to arrive before advancing the call. When the marker selected the circuit to New York a signal was immediately sent forward to summon a sender in the New York switching system. The process of attaching the sender in New York was carried on concurrently with the establishment of the connection through the switches in Atlanta.

When the New York sender is attached a signal is sent to the Atlanta sender to advise it that pulsing may proceed. It immediately sends the area code 207 to New York by MF pulsing and follows it with the remaining digits of the called number, AC4–2345, as they are received from the operator, ending with a start pulse, and then leaves the connection. All common control equipment in Atlanta is now free.

In New York, as soon as the Maine area code is received it is submitted to the decoder. Upon examination of the code the decoder finds that it is insufficient for routing purposes. New York has a direct circuit group to Portland over which traffic to some offices in Maine is routed, but other offices are reached through Bangor by way of Boston. In order to determine which route to take the decoder must know what office is desired. It, therefore, gives the sender a signal saying "come again when you have six digits" and leaves the connection. When the sixth digit arrives the sender again calls for a decoder and gives it the complete code 207–AC4.

The decoder again translates the area code, which now directs it to the foreign area translator which serves the Maine area, and submits the complete code to that translator. From the ensuing translation it learns that the route is by way of Boston and that all digits should be sent forward by MF. It then calls for a marker and releases the foreign area translator.

Subsequent operation is the same as previously described for Atlanta and the complete ten-digit number now arrives at Boston. At that point

both codes are again translated since Boston also has a choice of routes to Maine, and the route to Bangor is selected. The translating equipment in Boston knows that Bangor is in the Maine area and that the area code will, therefore, not be needed. However, since Bangor is a TO having no senders, the Boston sender must pulse forward all of the digits needed to complete the call through switches in Bangor, Houlton and Monticello. It is assumed that Houlton is arranged to route the call to Monticello on receipt of the digits AC4. Numerical digits 2345 will route the call through the Monticello switches to the called customer's line. These digits are all registered in the Boston sender but the digits required to switch the call through Bangor are not and must be supplied. An arbitrary set of digits beginning with "1" can be used for this purpose since no office code begins with "1" and there will, therefore, be no conflict.

The decoder in Boston, therefore, gives the sender the proper set of arbitrary digits, say 16, to be placed ahead of the office code AC4. The sender sends forward by the DP method 16–AC4–2345 driving switches in Bangor, Houlton and Monticello to the called subscriber's line, and ringing starts automatically. The talking connection is now established and the common control equipment at all intermediate points is free.

When the called subscriber answers, the Atlanta operator's cord lamp is extinguished. When he hangs up the lamp lights to denote end of conversation. The removal of the operator's cord automatically releases the entire connection, the release of each link causing the next in line to release.

In setting up this call all of the characteristic CSP features were employed, automatic alternate routing in Atlanta, six-digit translation in New York and Boston, digit storing and variable spilling at all CSP's with substitution of arbitrary digits for the area code at Boston.

TRANSMISSION

All talking connections through the CSP system are made on a four-wire basis, that is, separate pairs of conductors are provided for transmission in the two directions. This is done in order to simplify the problem of maintaining satisfactory balance so that the loss introduced by extra links in a connection can be held to a minimum value. The importance of this feature is emphasized by the fact that the switching plan permits as many as eight intertoll trunks to be connected in tandem for the completion of a call.

The advantages of four-wire switching were fully explained in the paper[2] on the toll crossbar system now in service.

SIGNALING

In following the progress of the call from Atlanta to Monticello, Maine, it was observed that besides the transmission of information in the form of digits it was necessary to pass a number of control and supervisory signals over the toll lines. These included seizure and disconnect signals in the forward direction and switchhook supervisory signals and sender attached signals in the reverse direction. On some calls it is also necessary to send flashing signals to indicate busy lines or trunks and ringing signals in either direction when operators are called in at intermediate or terminating points to assist in establishing connections.

For the early toll dialing installations the signaling method most widely used was the composite method whereby signaling channels for the three circuits of a phantom group are derived from three of the conductors with the fourth being used for earth potential compensation. Direct current is used for signaling. This is a simple, reliable and economical method of signaling and will continue to be used on circuits where it can be applied.

Where circuits are obtained from carrier systems, however, conductors are not available in sufficient numbers for signaling channels and other methods must be employed. Since carrier is used almost exclusively on the long haul circuits it was necessary to provide a signaling system to accompany it before toll dialing could be expanded beyond networks of limited range. To meet this situation a system[6] using a frequency of 1600 cycles was developed and has been in service since 1948. Signaling is done by application and removal of the 1600-cycle signaling current. The system is used in the same manner as the composite signaling system, to carry dial pulses as well as supervisory signals when used on circuits that require it. The set of leads brought out of the signaling unit are identical in function to those brought out of the composite signaling unit so that toll line relay circuits will operate in the same manner with either type of signaling.

Since 1600 cycles is in the voice range the signaling current can be carried over the same channel that carries the speech current but the signaling circuits must, of course, be protected against false operation due to speech and precautions must likewise be taken to insure that the signaling tone does not interfere with speech. Protection against interference between signaling and speech is more difficult at 1600 cycles than at higher frequencies because there is more energy in voice currents at the lower range. That value was chosen, nevertheless, so that it would be possible to operate over the narrow band circuits that were established to relieve shortages occasioned by the war.

A new 2600-cycle system to be used only on the broader band circuits has since been developed. It is simpler and more economical than the 1600-cycle system. The older carrier systems, having been designed when practically all toll operation was by the ringdown method, made no provision for signaling since that was all done by short applications of the 1000 cycles when there was no speech on the line. Some of the new carrier systems for short haul applications are designed to provide their own signaling channel for each voice channel.

PRINCIPAL ELEMENTS OF THE CSP SYSTEM

1. Crossbar Switch Frames

Crossbar switches are used for incoming and outgoing link frames on which the trunks (both toll lines and trunks to and from local offices and switchboards) are terminated, and for sender link frames used to give trunks access to senders. These frames are similar to those in the toll crossbar systems now in service. Since they have been described in a previous paper[1] they will be passed over with only a mention of their capacity.

Each incoming or outgoing link frame normally has terminals for 300 trunks. As many frames are provided as required for the size of the office. In the smaller offices one train of switches with complete interconnection of incoming and outgoing frames is provided. In the larger offices two trains each with its own set of markers are provided. When this is done the incoming trunks are multipled to both trains and an extra build out bay is provided on the incoming frame to provide 400 terminals per frame. Since each train has a theoretical limit of 40 incoming and 40 outgoing frames the maximum size of an office is theoretically 80 of each. Practical considerations, however, such as the number of markers that can be efficiently operated in a group and the maximum size office it is feasible to operate as a single administrative unit will limit an installation to about 60 incoming and 60 outgoing frames.

The sender link frame gives 100 trunks access to 40 senders.

2. Senders

Two separate groups of incoming senders are provided, one to receive DP and the other MF pulsing. Whether the system is installed in a step-by-step or a panel-crossbar area both groups of senders will always be needed. MF will be received from senders in other CSP's and from switchboard positions. DP will be received from switchboard positions

at TC's not equipped to send MF and in some cases from dialing A boards in the local area of the CSP itself.

Aside from the type of pulses received the functions of the two senders are identical. They have a capacity for receiving and sending eleven digits. They must register arbitrary digits given them by the decoder and send them out as directed. They will send out digits by either the DP or the MF method as required to control switches in distant offices, and in some installations will also send digits to an outgoing sender in the same office by the dc key pulsing method, which employs direct current in various combinations of value and polarity through a pair of conductors.

When the CSP is in a panel-crossbar area a group of outgoing senders is provided to transmit either the type of pulses required by the equipment in local panel offices or the type used to reach manual offices.

3. Markers

The marker has been stripped of its usual translating functions and performs most of its duties on instructions from the decoder. It is told what leads to test for idle circuits and where they are to be found in the trunk block connector, but having found an idle circuit it carries on the process of setting up the connection independently of the decoder. Having contact with both the incoming and outgoing trunks through connecting circuits, it determines what frames they are located on, connects itself to those frames, selects a path through them and sets up the connection.

In a single-train office one group of markers common to the office is provided. In a two-train office there is a group of markers associated with each train of switches.

4. Decoders

A single group of decoders serves the entire office whether one or two trains of switches are provided. An important element of the decoder is the translator which will be discussed separately.

The decoder contains several hundred relays. A large group is used for registering the information furnished by the translator. Others use this information to control the action of the markers and senders.

One group of decoder relays which is of particular interest is the array used for automatic selection of alternate routes. It is composed chiefly of one relay for each CSP to which the office has a direct group of toll lines. The relays are arranged in an orderly pattern simulating the

pattern of the CSP network for the country as seen from the CSP concerned and are interconnected in a pattern of progression corresponding to the fixed order of alternate route selection. Group busy leads from the toll line groups are connected to the contacts of the relays in such a manner that if a group is busy the relay corresponding to the next choice route in the chain will be operated. In this way the lowest choice route having an idle circuit will be speedily selected without testing individual trunks of separate groups. The decoder learns from the translator which relay in the array to operate first and the choice of the best route available follows automatically. The principle will be readily understood by reference to the simplified sketch in Fig. 3. Contacts not shown on the relays cause the translator to select the route corresponding to the last relay operated in the chain.

5. *Translators*

The magnitude of the translating job for nationwide dialing led to the decision to develop a new translator operating on a principle radically different from that employed in other crossbar systems. In previous systems translation is done by relays. The code digits – never more than three – operate a group of relays which cause a single terminal corresponding to the code to be selected. A cross-connection is made between

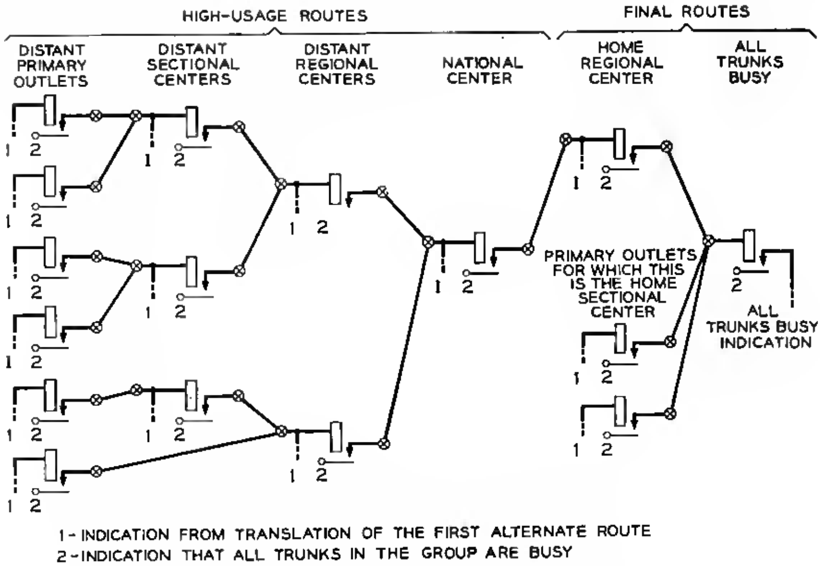


Fig. 3—Alternate route array for the decoder at a sectional center.

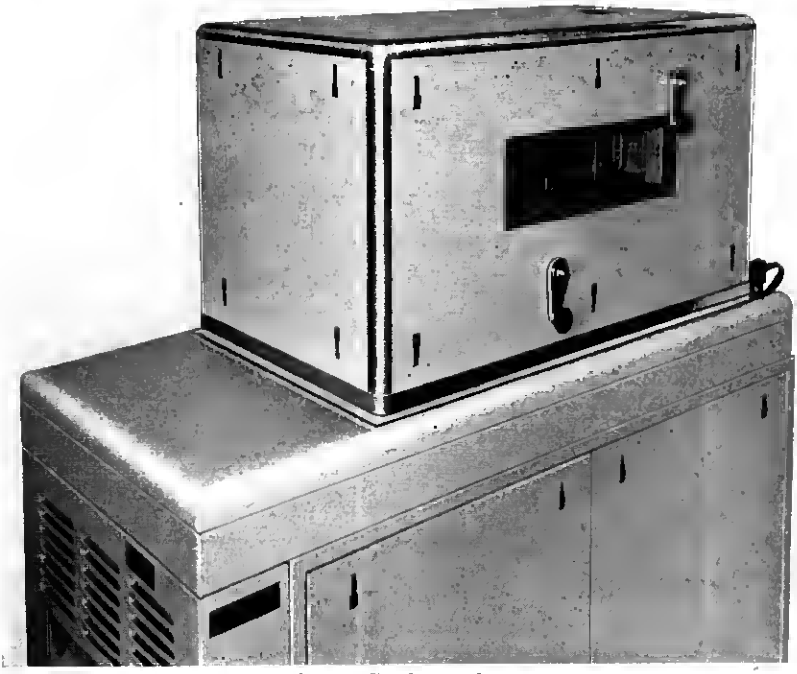


Fig. 4—Card translator.

the code point and a route relay associated with the trunk group to be selected. The route relay has a number of contacts which are cross-connected to supply the information required for proper routing of the call. When changes in routing or equipment location of trunks within the office are made it is necessary to change cross-connections.

With the nationwide dialing plan in operation routing changes or opening of new offices in one part of the country will necessitate translator changes in many offices, some of them far removed from the scene of the event that forces them to be made. The changes in any one CSP will, therefore, be frequent and to make them by running cross-connections would be cumbersome and expensive. The new translator uses punched cards instead of relays, making it possible to effect changes by the simple process of removing old cards and inserting new ones in a machine. This can be done in a very short time and not only saves labor but requires less out-of-service time for the equipment. Fig. 4 is a photograph of the machine.

A metal card about 5 by $10\frac{3}{4}$ inches is provided for each area code and also one for each office code that must be translated in a particu-

lar CSP, the cards representing destinations. The capacity of a single machine is about 1000 cards. The cards are lined up in a box as in a filing drawer, with tabs along the bottom of the card resting on select bars which run the length of the box. One-hundred and eighteen holes are punched out in all cards in fixed positions so that in the normal condition 118 tunnels are formed from one end to the other. A light source at one end of the box shines through the tunnels upon phototransistors (Fig. 5) at the other end but the phototransistors are disabled until, concurrently with the dropping of a card, voltage is applied to them.

All tabs along the bottom of the card are cut off except those which serve to identify the particular card. When a code is presented to the machine a combination of select bars corresponding to the code is

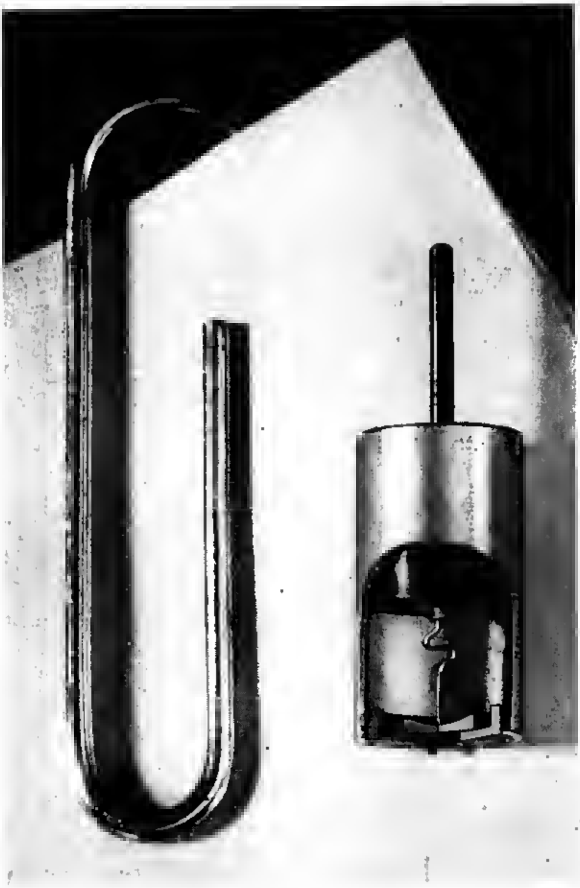


Fig. 5—Transistor.

lowered. The card having all tabs cut off except those resting on the lowered bars will drop but all other cards will remain in place. If nothing further were done the dropping of the card would cut off all light channels but on each card some holes are enlarged and through these holes the light continues to shine, energizing the corresponding phototransistors. The combination of enlarged holes furnishes all of the information needed for routing the call to the destination represented by the card.

Fig. 6 shows the functions of the various groups of tabs and holes. The designations will not appear on the actual card. Fig. 7 is a photograph of an actual card prepared for use.

a. Selecting Tabs – Input Information. The sole use of the information presented to the card translator is to enable it to select the proper card. The information presented is in the form of code digits with accompanying indications of their nature. The information is recognized by cutting off tabs along the bottom of the card in proper combinations.

The groups of tabs labeled A, B, C, D, E and F are for the six code digits. For each digit used two tabs are left since the digits are registered in the sender on a two-out-of-five basis and the leads from the sender will operate the select bars directly. If the card represents an ordinary three-digit code all tabs will be cut off except two each of the A, B and C tabs, two of the four CG tabs and perhaps either the VO or NVO tab. The CG (card group) tabs are used in combination to indicate three-digit, six-digit and alternate route card groups. The VO and NVO (via only and not via only) tabs are used when the group of toll lines over which the call will be routed is divided into one subgroup of a transmission grade suitable for only terminal traffic and another subgroup for either terminal or switched traffic. If the card represents an ordinary six-digit code two tabs will be left in each of the digit positions, and a different pair in the CG group.

b. Punch Holes – Output Information. The output information from the card translator is recognized in the decoder and marker by relays operated in the combinations set up by enlargement of associated holes in the card. The output from the phototransistors is amplified by other transistors to fire cold cathode tubes which in turn operate the relays.

The pretranslation group on the top line of Fig. 7 indicates how many digits the sender must supply for a complete translation. The term "pretranslation" implies that further translation is required. This is not always true. In many cases only the first three digits need to be translated and all information needed for routing the call is supplied by this card. In many cases the six digits of the area and office code are needed and the routing information will be on another card to be selected

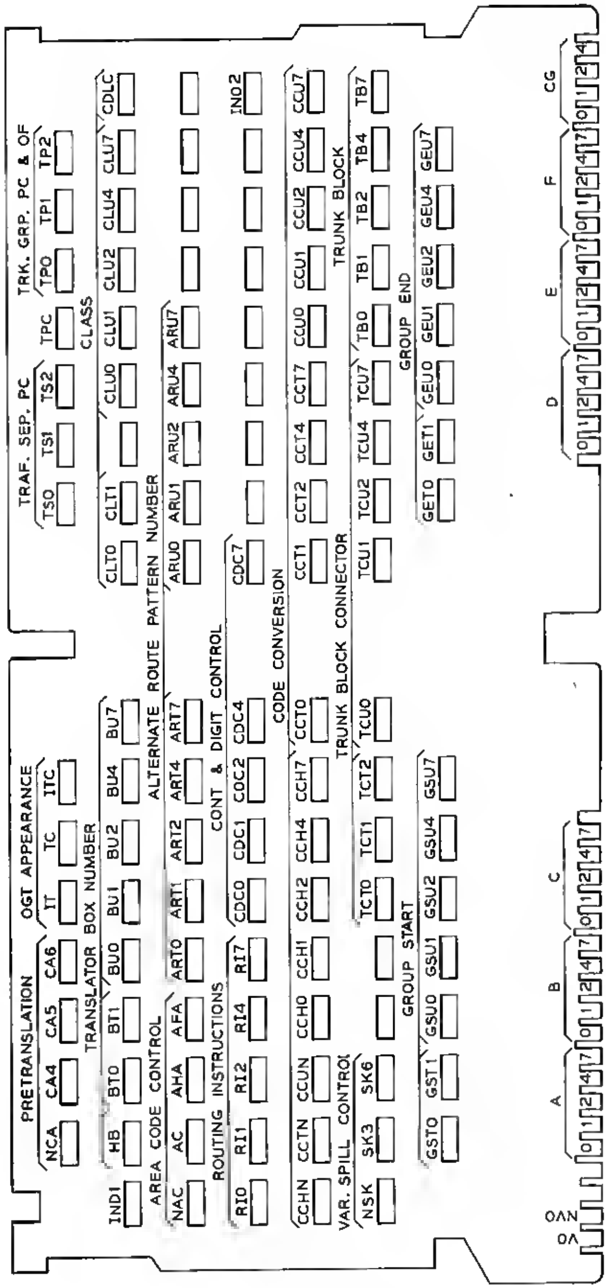


Fig. 6—Card layout.

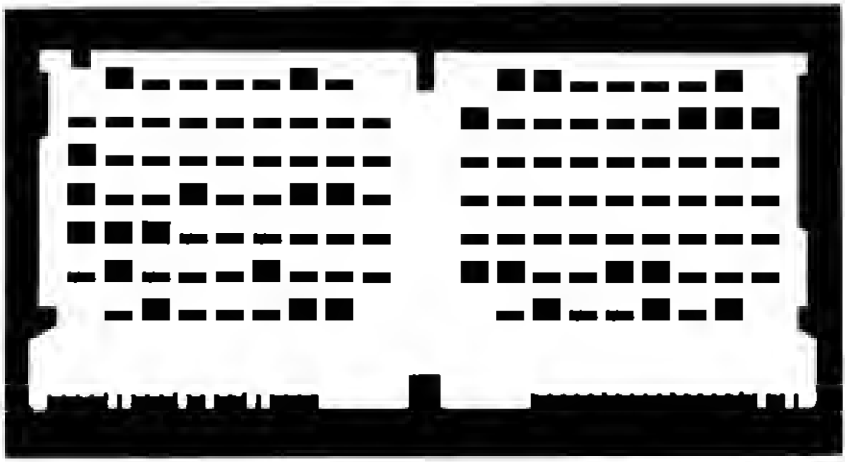


Fig. 7—Punched card.

later. For certain calls such as calls to operators only four or five digits are needed. These are treated as six-digit calls by having the sender supply the extra one or two digits to fill the complement. The NCA hole enlarged means "no come again", that is, three digits are sufficient, and translation will proceed. The other holes enlarged mean respectively "come again when you have four, five or six digits", and no further translation is done until the sender comes back a second time, probably to a different decoder, with an indication that it has the required number of digits.

The OGT appearance holes are used in a two-train office to tell which train the outgoing trunk appears on and enable the decoder to select a marker in the proper group.

The remaining holes on the top lines are for controlling operation of traffic meters.

The translator box number holes in the second line are punched on the area code cards to indicate which machine contains the individual cards for the called area when six-digit translation is required.

The IND1 hole in the second line and the IND2 hole in the fourth line are index holes and are never enlarged. Any card that drops will always cut off the light through those channels. This serves as an indication that a card has actually dropped and that the phototransistors associated with the other holes should be prepared for action. The index holes also aid in trouble detection and in proper disposition of calls where cards are deliberately omitted or where operators have dialed a blank code in error.

The class holes indicate such things as type of pulsing and nature of the signaling channel used on the trunk group out of the office.

The area code control holes in the third line are to tell the decoder what to do about dropping or spilling forward an area code registered in the sender or supplying an area code when none is registered. This information is needed primarily in connection with alternate routing.

The alternate route pattern number holes tell the decoder at what point to enter its chain of alternate route relays for the first choice alternate. Provision is made for a maximum of 100 entry points.

The holes on the fourth line are for making proper disposition of calls when no circuits are available on any routes, telling how many digits to expect on certain calls and other items of a detailed technical nature.

The code conversion holes on the fifth line supply the arbitrary digits to replace code digits on calls routed through step-by-step TO's or TC's. Provision is made for one, two or three digits as required.

The variable spill control holes in the sixth line tell whether to spill all digits received, skip the first three code digits or skip six code digits.

The remaining holes define the location on the equipment of the test leads for the trunk group over which the call will be routed.

The notches around the edges are used for proper positioning and removal of cards.

An individual card is removed from the stack by first keying the code to cause it to drop so that it may be identified. Since a card can easily be located in this manner it is unnecessary to keep cards in any ordered position in the box.

At least one translator is provided in every decoder. It contains the cards for all offices in the home numbering area of the CSP, for certain operator codes, the single three-digit card for each toll numbering area and a card for each toll line group out of the office that can be used as an alternate route. If there are other areas to which the volume of traffic is very high and for which six-digit translation is required the cards for those areas are put in a second machine in each decoder. Cards for other areas are put in foreign area translators common to the office and accessible to all decoders on a one-at-a-time basis. An emergency translator is provided to permit removal of all cards to it from any translator which may require prolonged repair work.

6. Traffic Control Panel

The traffic control panel is located in the operating room. The equipment in it consists of a key for each group used as an alternate route. When a particular key is operated no alternate routed traffic will be

offered to the group represented by it nor to any group above it in the fixed alternate route pattern. This is done to relieve offices which are overloaded by either unforeseen or predicted traffic peaks.

MAINTENANCE

The maintenance facilities for the new CSP system are basically similar to those of the older toll crossbar system with the necessary addition of equipment to test the new features introduced. The sender test frame is, of course, obliged to test the CSP features added to the sender and the trouble indicator frame is changed to operate with the new decoders, translators and markers.

In place of the lamp trouble indicator the new trouble recorder introduced with the latest local crossbar system[7] is used. Whenever trouble is encountered it punches on a card a record of the circuits involved and of the important events that had occurred in the progress of the call, as an aid to the maintenance man in locating the trouble. A sample trouble recorder card is shown in Fig. 8.

Automatic equipment for testing the operation and transmission features of intertoll trunks has also been designed both for the older systems and for the new CSP system.

SWITCHING ASPECTS OF CUSTOMER TOLL DIALING

In the course of developing the switching system for CSP's the requirement for handling long distance traffic dialed by customers as well as that dialed by operators was kept in mind. The trial of long distance customer dialing now in progress in Englewood, N. J., confirms the soundness of the basic plan and exemplifies the principles involved in full realization of the plan. With a toll network laid out to accept a distinctive ten-digit number for any telephone in the country and route it to the proper destination, the remaining tasks to be performed are to provide for delivery of the number to the toll network from the customer's dial instead of from an operator and to provide an automatic record of the call for charging purposes.

In Englewood both tasks were quite easily performed. The Englewood local office equipment is of the most modern type[7] and includes AMA[8] facilities. When it was in the development stage the ultimate requirement for nationwide customer dialing was foreseen and provision was made for expanding the digit capacity of the switching equipment at small expense. Also the designs of the accounting center were such that corresponding changes could readily be made. In the new local office switching

system, arrangements were included for sending forward the complete number, as received, to the toll office by MF pulsing. The system was also designed to be capable of automatic alternate routing and this feature is used in the trial.

Expansion of the program will, of course, demand that similar arrangements be provided for the older types of local switching systems already in service. More extensive modification will be required to make them capable of giving the customer the same service. For them, as for the most modern system, however, AMA equipment is admirable for recording the information necessary for charging for the calls.

The requirement for customer toll dialing that senders (or directors) and recording equipment be provided has a bearing on the type of equipment used at TC's and TO's. For calls handled by operators and for calls received by the customers through such offices the only disadvantage of step-by-step equipment without senders at those points is that the CSP equipment at other points must be somewhat more complicated and expensive than it would otherwise need to be. But with customer dialing, if senders and recording equipment are not provided either in the local office or in the TC or TO, the calls must be routed by the most direct means possible to a CSP where such equipment is provided. Thus some advantages that might be gained from having them at the TC or TO would be lost:

1. In some cases an indirect route to the CSP would need to be taken for the sole purpose of recording the call. For example, a call which might normally be switched from a TC through a TO to another TC would need to be connected to the CSP for making the record.

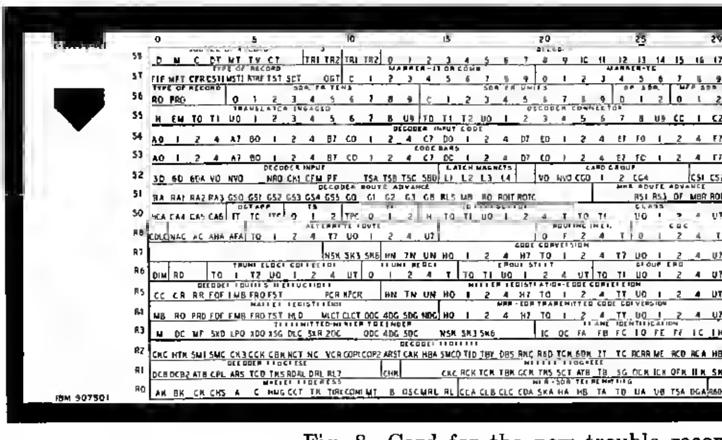


Fig. 8—Card for the new trouble recor

2. There is no operator at the TC or TO to select an alternate route and with the equipment there incapable of automatic alternate routing the economies and service protection inherent in the alternate routing procedure would be lost.

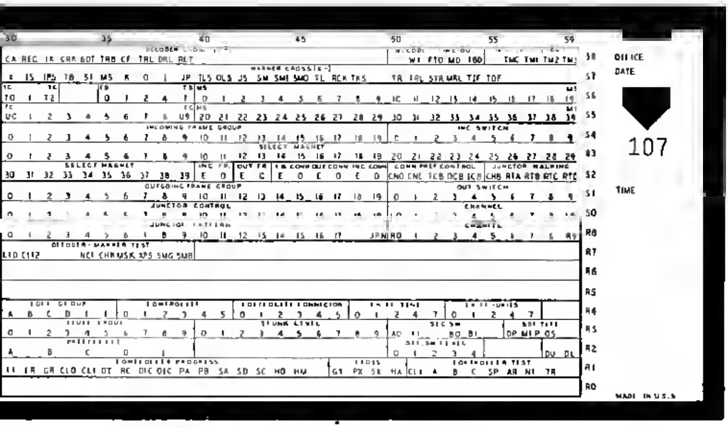
If step-by-step toll switching equipment is already provided at a TC or TO, senders (or directors) could be added, making it in effect a common control switching system. This measure would permit automatic alternate routing and the further addition of recording equipment would eliminate the indirect routings for recording purposes.

A further benefit from having common control equipment in TC's or TO's can be realized in some instances. When a customer is served by a local office that has no senders he must dial one or more directing digits (probably three digits) ahead of the seven or ten-digit number in order to get to an office where senders are provided. It is, of course, desirable to avoid this extra burden on the customer. Where the equipment in a TC or TO can be used in common for switching local and toll traffic the customers whose lines are terminated in that office will be dialing directly into senders, if the equipment uses common control, and will, therefore, benefit in that they will not have to dial directing digits.

CONCLUSION

The new system was designed to implement the nationwide switching plan, which integrates the switching network of the entire nation into a single unit. This switching job, requiring a high order of mechanical intelligence, is the most comprehensive ever performed by any system.

The skillful manipulation of code digits enables the provision of a



duced with the latest local crossbar system.

numbering plan covering the entire country with a minimum number of digits to give each customer a distinctive number. It also obviates the need for extra expense to make step-by-step toll offices satisfactory operating elements of the plan in those locations where CSP features are not essential.

The automatic and almost instantaneous selection of alternate routes makes it possible to give virtual no-delay service without greatly increasing the cost of outside plant and to make multi-switch connections at a speed comparable to that for local service.

The translating equipment simplifies administration of the plan which demands coordination of activities on a nationwide basis.

The numbering plan, the switching plan and the CSP equipment which implements them make it feasible to offer nationwide dialing service to customers without the aid of operators when automatic charging facilities and local office switching arrangements for handling the three extra digits of the national number are provided. It will be readily appreciated that so far as the CSP switching equipment is concerned it is immaterial whether the digits it receives come from an operator or from a customer. The call will be routed to its destination and supervision for charging purposes will be furnishes in the same manner in either event.

The new system represents an important step in the process of continually improving the long distance switching methods of the Bell System with consequent improvement of the service to all telephone customers in the United States and Canada.

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